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CHARACTER ASSOCIATION AND PATH ANALYSIS FOR YIELD COMPONENTS AND GRAIN QUALITY PARAMETERS OF RICE (*ORYZA SATIVA* L.)

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ABSTRACT

The character association studies revealed that the traits number of productive tillers per plant, number of total grains per panicle, test weight and milling percentage had significant positive association with grain yield at both phenotypic and genotypic levels. So, advancement in grain yield is possible by giving emphasis on these characters in selection scheme. Path coefficient analysis revealed that the characters plant height, number of productive tillers per plant, panicle length, number of grains per panicle, test weight and days to maturity showed positive direct effect and positive correlation with grain yield per plant.

KEYWORDS: Character Association, Path Analysis, Yield Components, Quality Parameters, Rice

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Original Article

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food for about 3.0 billion world's population which may escalate to 4.6 billion by 2050. Rice fulfils the nutritional requirements of half of the world's population and 90 per cent population of Asian countries. In India, rice is a major food crop supplying 30% of the calorie requirement to the Indian population (Maclean, 2002). The estimation of character association could identify the relative importance of independent character (s) that may be useful as indicator(s) for one or more characters. Similarly, path coefficient analysis partitions the genetic correlation between yield and its components into direct and indirect effects. In the present study, an attempt was made to understand the association and path analysis of yield component and grain quality parameters for grain yield to provide basis for selection and yield improvement.

MATERIAL AND METHODS

Sixty four genotypes obtained from Indian Institute of Rice Research (IIHR), Ranjendranagar were evaluated in a Simple Lattice Design (SLD) with two replications during *Kharif,* 2014 at Agriculture college farm, Bapatla. Each genotype was raised in two rows of five meter length with a spacing of 20 x15 cm between and within the rows respectively. Standard agronomic practices and recommended fertilizer doses were adopted for normal crop growth. Observations were recorded on ten randomly selected plants from each replication for five yield components *viz.,* plant height, number of productive tillers, panicle length, number of total grains per panicle, and grain yield per plant. Three yield components *viz.,* days to 50% flowering, days to maturity and test weight; and all The quality parameters *viz.*, milling percentage, hulling percentage, head rice recovery, L/B ratio, water uptake, kernel elongation ratio, volume expansion ratio, amylose content and protein percentage estimated replication-wise on plot basis as per the standard procedures delineated by DRR Laboratory Manual on Rice Grain

Quality Procedures. Phenotypic and genotypic correlations were worked out by using the formulae suggested by Falconer (1964). Path coefficient analysis suggested by Wright (1921) and elaborated by Dewey and Lu (1959) was used to calculate the direct and indirect contribution of various traits to yield.

RESULTS AND DISCUSSIONS

The phenotypic and genotypic correlation coefficients for different grain yield components and quality parameters are presented in Tables 1 and Table 2. Character association studies revealed positive significant correlation of number of productive tillers per plant (0.4091** and 0.2034*) (Bornare *et al*., 2014), number of total grains per panicle (0.6951** and 0.7874**) (Panwar *et al*., 2006) and test weight (0.3398* and 0.3844) (Rashid *et al*., 2014) at both phenotypic and genotypic level with grain yield per plant. Improvement of grain yield might be possible if the above traits were considered in the selection programme. It was also observed that the association of days to 50% flowering (0.0048 and 0.0362), days to maturity (0.0160 and 0.0.3420**), panicle length (0.0729 and 0.095), hulling percentage (0.1250 and 0.0721), volume expansion ratio (0.1236 and 0.1467), L/B ratio (0.1219 and 0.1062) and protein percentage (0.0124 and 0.0222) showed non-significant positive association at genotypic level with grain yield per plant (g). Head rice recovery per cent (-0.1912 and -0.2109) (Naik *et al*., 2005) showed significant negative association with grain yield per plant at both phenotypic and genotypic levels. Plant height (0.1603 and 0.2290*) (Bekale *et al*., 2013) showed non-significant positive association at phenotypic level and significant positive association with grain yield per plant at genotypic level. Amylose content (0.1542 and -0.3234**) (Parvathi *et al*., 2010) showed non-significantly negative and significantly negative association with grain yield per plant at phenotypic and genotypic level respectively. Milling percentage (0.1250 and -0.1603) (Nagajyothi, 2001) and water uptake (-0.0625 and 0.1207) showed non-significant negative association with grain yield at both phenotypic and genotypic level. However, the simultaneous improvement of these negatively associated traits might be possible through random matings or paired matings in F_2 and subsequent segregating generations.

Results of path coefficient analysis concluded that simple selection based on character with direct positive effect towards grain yield per plant and positive correlation with grain yield per plant *viz.,* number of total grains per panicle (0.6275 and 0.6951**) (Nagajyothi, 2001), number of productive tillers per plant (0.1619 and 0.4091**) (Garg *et al*., 2010), test weight (0.0295 and 0.3398**) (Gangashetty *et al*., 2013) and days to maturity (0.1065 and 0.0160) *i.e.,* profuse tillering plants having more number of grains per panicle with more test weight and more days to maturity might be resulted in higher yield in rice genotypes studied. Days to 50% flowering (-0.1595 and 0.0048) (Babu *et al*., 2012), plant height (-0.0566 and 0.1603) (Rangare *et al*., 2012) and protein percentage (-0.0308 and 0.024) (Nagajyothi, 2001) are the characters with negative direct effect and positive association with grain yield per plant. The negative direct effects and positive associations explained the indirect effects seem to be the cause of positive correlation and the indirect causal factors are to be considered simultaneously for selection. Grain quality parameters like hulling per cent, water uptake, volume expansion ratio and L/B ratio of grain might be improved independent of the yield. The direct and indirect effects of different components on yield at phenotypic and genotypic levels are presented in Table 3 and Table 4; and path diagrams are presented in Figure 1 and Figure 2, respectively.

CONCLUSIONS

Character association studies indicated significant positive association of number of productive tillers per plant, number of total grains per panicle, test weight and milling percentage. Hence, selection of these traits would be more effective to bring simultaneous improvement in grain yield and to evolve high yielding varieties in rice. Path coefficient analysis revealed that selection based on characters showed direct positive effect toward yield and positive correlation with yield *viz.,* number of total grains per panicle, number of productive tillers per plant, test weight and days to maturity *i.e.,* profuse tillering plants having more number of grains per panicle with more test weight and more days to maturity might results in higher yield in rice genotypes. Grain quality parameters like volume expansion ratio, L/B ratio and protein per cent of grain might be improved independent of the yield.

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APPENDICES

Table 1: Estimates of Phenotypic Correlation Coefficients among Yield and Yield Components in Rice (*Oryza Sativa* L.)

Character	Days to 50% Flowering	Days to Maturity	Plant Height	Productive tillers/ Plant	Panicle Length	No. Of Grains/ Panicle	Test Weight	Hulling %	Milling %	Head Rice Recovery	Volume Expansion Ratio	Water Uptake	L/B Ratio	Kernel Elongation Ratio	Protein %	Amylose Content	Grain Yield/Plant
Days to 50% flowering	**1.0000**	0.9199**	0.1906*	0.0160	0.0216	0.0524	0.0532	-0.0541	0.0156	0.0768	0.0016	-0.1566	0.1851*	0.1350	0.1271	0.0617	**0.0048**
Days to maturity		**1.0000**	0.1844*	0.0258	0.0111	0.0387	0.0574	-0.0554	0.0010	0.0715	0.0079	-0.1800*	0.1411	0.1180	0.1338	0.0624	**0.0160**
Plant height			**1.0000**	0.0824	-0.0717	0.2980*	0.3710**	-0.1006	-0.0926	0.0206	0.0981	-0.0526	0.0988	-0.1428	-0.1121	-0.0065	**0.1603**
Productive tillers /plant				**1.0000**	-0.0061	0.3724*	0.1866*	0.0086	-0.0398	-0.0949	0.0329	-0.0611	-0.0241	-0.1176	-0.0656	-0.1567	**0.4091****
Panicle length					**1.0000**	0.0485	0.0174	0.1725	0.1016	-0.1634	0.1078	0.1791*	-0.0619	-0.0015	-0.0133	0.2106*	**0.0729**
No. Of grains/ panicle						**1.0000**	0.4352**	0.1085	-0.0685	-0.0766	0.0339	0.0182	0.0461	-0.0997	0.0593	-0.1843*	**0.6951****
Test weight							**1.0000**	-0.1351	-0.0882	0.0493	0.1095	-0.1799*	0.0233	-0.0115	-0.1062	-0.0192	**0.3398****
Hulling%								**1.0000**	0.6171**	0.1327	-0.1243	0.0345	-0.0276	0.0655	-0.1038	-0.0121	**0.0545**
Milling %									**1.0000**	0.4632**	-0.0671	-0.0900	0.1112	-0.1805*	0.0120	-0.036	**-0.1250**
Head rice recovery %										**1.0000**	-0.0679	-0.2114*	0.0338	-0.0095	0.2052*	-0.244**	**-0.1912***
Volume expansion ratio											**1.0000**	-0.0631	-0.0154	0.1396	0.0473	-0.1711	**0.1236**
Water uptake												**1.0000**	0.0332	0.0562	-0.224 *	0.2128*	**-0.0625**
L/B ratio													**1.0000**	-0.0095	0.1593	-0.0908	**0.1219**
Kernel elongation ratio														**1.0000**	0.0863	-0.0531	**0.0036**
Protein %															**1.0000**	-0.2199*	**0.0240**
Amylose content																**1.0000**	**-0.1542**
Grain yield per plant																	**1.0000**

*significant at 5% level, ** significant at 1% level

Table 2: Estimates of Genotypic Correlation Coefficients among Yield and Yield Components in Rice (*Oryza Sativa* L.)

Character	Days to 50% Flowering	Days to Maturity	Plant Height (cm)	Productive Tillers/ Plant	Panicle length (cm)	No. of Grains/ Panicle	Test weight	Hulling %	Milling %	Head Rice Recovery	Volume Expansion Ratio	Water uptake	L/B ratio	Kernal elongation ratio	Protein %	Amylose Content	Grain Yield/ Plant (g)
Days to 50% flowering	**1.0000**	0.9289**	0.2338**	0.2236*	-0.0116	0.0496	0.0646	-0.0759	0.0461	0.0819	0.0134	-0.1799*	0.1981*	0.1751*	0.1271	0.0569	**0.0362**
Days to maturity		**1.0000**	0.2624**	0.2275**	-0.0163	0.0823	0.0666	-0.0851	0.0675	0.0981	-0.0011	-0.1541	0.2863**	0.2122*	0.1301	0.0588	**0.0342**
Plant height			**1.0000**	-0.1888	-0.0811	0.3361**	0.4092**	-0.1056	-0.1040	0.0325	0.0928	-0.0434	0.1449	-0.1525	-0.1394	0.0382	**0.2229***
Productive tillers/ plant				**1.0000**	-0.1907*	-0.2246*	0.2979**	-0.1248	0.3443**	0.3572**	-0.0861	-0.2329**	-0.0873	0.273**	0.2778**	0.2202*	**0.2034***
Panicle length					**1.0000**	0.0470	0.0486	0.1712	0.1064	-0.1795*	0.1214	0.2017*	-0.076	-0.0190	0.0370	0.3193**	**0.0950**
No. Of grains/ panicle						**1.0000**	0.4616**	0.1074	-0.0741	-0.0812	0.0451	0.0301	0.0229	-0.1089	0.0590	-0.2602**	**0.7874****
Test weight							**1.0000**	-0.1511	-0.0899	0.0535	0.1131	-0.2213*	0.0253	-0.0163	-0.1257	0.0034	**0.3844****
Hulling %								**1.0000**	0.6723**	0.1429	-0.1336	0.0137	-0.0218	0.0975	-0.1247	-0.025	**0.0721**
Milling %									**1.0000**	0.4837**	-0.0671	-0.0886	0.1157	-0.2137*	0.0206	-0.0401	**-0.1603**
Head rice recovery										**1.0000**	-0.0707	-0.2468**	0.0396	-0.0037	0.2421**	-0.3173**	**-0.2109***
Volume expansion ratio											**1.0000**	-0.0505	0.0086	0.1792*	0.0289	-0.1879*	**0.1467**
Water uptake												**1.0000**	-0.0521	0.1057	-0.2286**	0.284**	**-0.1207**
L/B ratio													**1.0000**	-0.0183	0.1961*	-0.1751*	**0.1062**
Kernal elongation ratio														**1.0000**	0.1140	-0.0468	**-0.004**
Protein %															**1.0000**	-0.2702**	**0.0222**
Amylose content																**1.0000**	**-0.3239***
Grain yield/ plant																	**1.000**

*significant at 5% level, ** significant at 1% level

Table 3: Direct and Indirect Effects (Phenotypic) of Yield Components on Yield among 64 Genotypes of Rice (*Oryza Sativa* L.)

Character	Days to 50% Flowering	Days to Maturity	Plant Height	Productive Tillers/ Plant	Panicle Length	Grains/ Panicle	Test Weight	Hulling %	Milling %	Head Rice Recovery	Volume Expansion Ratio	Water Uptake	L/B Ratio	Kernel Elongation Ratio	Protein %	Amylose Content
Days to 50% flowering	**-0.1595**	-0.1468	-0.0304	-0.0026	-0.0034	-0.0084	-0.0085	0.0086	-0.0025	-0.0123	-0.0003	0.025	-0.0295	-0.0215	-0.0203	-0.0098
Days to maturity	0.0979	**0.1065**	0.0196	0.0027	0.0012	0.0041	0.0061	-0.0059	0.0001	0.0076	0.0008	-0.0192	0.0150	0.0126	0.0142	0.0066
Plant height	-0.0108	-0.0104	**-0.0566**	-0.0047	0.0041	-0.0169	-0.0210	0.0057	0.0052	-0.0012	-0.0056	0.003	-0.0056	0.0081	0.0063	0.0004
Productive tillers/ plant	0.0026	0.0042	0.0133	**0.1619**	-0.0010	0.0603	0.0302	0.0014	-0.0064	-0.0154	0.0053	-0.0099	-0.0039	-0.0190	-0.0106	-0.0254
Panicle length	0.0010	0.0005	-0.0032	-0.0003	**0.0448**	0.0022	0.0008	0.0077	0.0046	-0.0073	0.0048	0.0080	-0.0028	-0.0001	-0.0006	0.0094
Grains/ panicle	0.0329	0.0243	0.1870	0.2337	0.0304	**0.6275**	0.2731	0.0681	-0.043	-0.0481	0.0213	0.0114	0.0289	-0.0626	0.0372	-0.1156
Test weight	0.0016	0.0017	0.0109	0.0055	0.0005	0.0128	**0.0295**	-0.0040	-0.0026	0.0015	0.0032	-0.0053	0.0007	-0.0003	-0.0031	-0.0006
Hulling %	-0.0016	-0.0017	-0.0030	0.0003	0.0052	0.0033	-0.0041	**0.0300**	0.0185	0.0040	-0.0037	0.0010	-0.0008	0.0020	-0.0031	-0.0004
Milling %	-0.0008	-0.0001	0.0050	0.0022	-0.0055	0.0037	0.0048	-0.0335	**-0.0543**	-0.0251	0.0036	0.0049	-0.0060	0.0098	-0.0007	0.0020
Head rice recovery	-0.0086	-0.0081	-0.0023	0.0107	0.0184	0.0086	-0.0056	-0.0149	-0.0522	**-0.1126**	0.0076	0.0238	-0.0038	0.0011	-0.0231	0.0276
Volume expansion ratio	0.0001	0.0006	0.0071	0.0024	0.0078	0.0024	0.0079	-0.0090	-0.0048	-0.0049	**0.0721**	-0.0045	-0.0011	0.0101	0.0034	-0.0123
Water uptake	0.0182	0.0209	0.0061	0.0071	-0.0208	-0.0021	0.0209	-0.0040	0.0104	0.0245	0.0073	**-0.1161**	-0.0039	-0.0065	0.0261	-0.0247
L/B ratio	0.0259	0.0198	0.0139	-0.0034	-0.0087	0.0065	0.0033	-0.0039	0.0156	0.0047	-0.0022	0.0046	**0.1402**	-0.0013	0.0223	-0.0127
Kernel elongation ratio	0.0100	0.0087	-0.0106	-0.0087	-0.0001	-0.0074	-0.0008	0.0048	-0.0134	-0.0007	0.0103	0.0042	-0.0007	**0.0740**	0.0064	-0.0039
Protein %	-0.0039	-0.0041	0.0035	0.0020	0.0004	-0.0018	0.0033	0.0032	-0.0004	-0.0063	-0.0015	0.0069	-0.0049	-0.0027	**-0.0308**	0.0068
Amylose content	-0.0001	-0.0001	0.0001	0.0002	-0.0003	0.0003	0.0020	0.0030	0.0001	0.0004	0.0002	-0.0003	0.0001	0.0001	0.0003	**-0.0014**
Grain yield/ plant	**0.0048**	**0.016**	**0.1603**	**0.4091****	**0.0729**	**0.6951****	**0.3398****	**0.0545**	**0.1251**	**-0.1912***	**0.1236**	**-0.0625**	**0.1219**	**0.0036**	**0.024**	**-0.1542**
Partial r^2	-0.0008	0.0017	-0.0091	0.0662	0.0033	0.4361	0.01	0.0016	0.0068	0.0215	0.0089	0.0073	0.0171	0.0003	-0.0007	0.0002

*significant at 5% level, ** significant at 1% level R SQUARE = 0.5705 Residual Effect = 0.6554 Diagonal bold letters indicate direct effect

Table 4: Direct and Indirect Effects (Genotypic) of Yield Components on Yield among 64 Genotypes of Rice (*Oryza Sativa* L.)

Character	Days to 50% Flowering	Days to Maturity	Plant Height	Productive Tillers/ Plant	Panicle Length	Grains/ Panicle	Test Weight	Hulling %	Milling %	Head rice Recovery %	Volume expansion ratio	Water uptake	L/B ratio	Kernel elongation ratio	Protein %	Amylose Content
Days to 50% flowering	**-0.0380**	-0.0429	-0.0089	0.0968	0.0004	-0.0019	-0.0025	0.0029	-0.0018	-0.0031	-0.0005	0.0068	-0.0075	-0.0066	-0.0048	-0.0022
Days to maturity	0.1859	**0.1647**	0.0432	-0.0007	-0.0027	0.0136	0.0110	-0.0140	0.0111	0.0161	-0.0002	-0.0254	0.0471	0.0349	0.0214	0.0097
Plant height	-0.0558	-0.0626	**-0.2388**	0.0651	0.0194	-0.0803	-0.0977	0.0252	0.0248	-0.0078	-0.0222	0.0104	-0.0346	0.0364	0.0333	-0.0091
Productive tillers/ plant	-0.0954	-0.0963	-0.0406	**0.2152**	-0.0410	-0.3711	-0.1717	-0.0268	0.0741	0.0769	-0.0185	-0.0501	-0.0188	0.0587	0.0598	0.0474
Panicle length	-0.0015	-0.0021	-0.0104	-0.0245	**0.1286**	0.006	0.0063	0.0220	0.0137	-0.0231	0.0156	0.0260	-0.0098	-0.0024	0.0048	0.0411
Grains/ panicle	0.0556	0.0923	0.3768	-0.1699	0.0527	**1.1210**	0.5175	0.1204	-0.0830	-0.0910	0.0505	0.0337	0.0257	-0.1220	0.0661	-0.2917
Test weight	0.0032	0.0033	0.0203	-0.0396	0.0024	0.0229	**0.0497**	-0.0075	-0.0045	0.0027	0.0056	-0.0110	0.0013	-0.0008	-0.0062	0.0002
Hulling %	-0.0121	-0.0136	-0.0169	-0.0199	0.0274	0.0172	-0.0242	**0.1598**	0.1074	0.0228	-0.0214	0.0022	-0.0035	0.0156	-0.0199	-0.004
Milling %	-0.0138	-0.0201	0.0310	-0.0027	-0.0318	0.0221	0.0268	-0.2006	**-0.2984**	-0.1443	0.0200	0.0264	-0.0345	0.0638	-0.0061	0.0120
Head rice recovery %	-0.0072	-0.0087	-0.0029	0.0916	0.0159	0.0072	-0.0047	-0.0126	-0.0428	**-0.0885**	0.0063	0.0218	-0.0035	0.0003	-0.0214	0.0281
Volume expansion ratio	0.0013	-0.0001	0.0089	-0.0083	0.0117	0.0043	0.0109	-0.0128	-0.0065	-0.0068	**0.0962**	-0.0049	0.0008	0.0172	0.0028	-0.0181
Water uptake	0.0274	0.0235	0.0066	0.0355	-0.0307	-0.0046	0.0337	-0.0021	0.0135	0.0376	0.0077	**-0.1523**	0.0079	-0.0161	0.0348	-0.0433
L/B ratio	0.0300	0.0434	0.0220	-0.0032	-0.0115	0.0035	0.0038	-0.0033	0.0175	0.0060	0.0013	-0.0079	**0.1515**	-0.0028	0.0297	-0.0265
Kernel elongation ratio	-0.0111	-0.0134	0.0097	-0.0264	0.0012	0.0069	0.0010	-0.0062	0.0135	0.0002	-0.0114	-0.0067	0.0012	**-0.0634**	-0.0072	0.0030
Protein %	-0.0252	-0.0258	0.0276	-0.0001	-0.0073	-0.0117	0.0249	0.0247	-0.0041	-0.0480	-0.0057	0.0453	-0.0389	-0.0226	**-0.1982**	0.0535
Amylose content	-0.0071	-0.0073	-0.0047	-0.0053	-0.0396	0.0323	-0.0004	0.0031	0.0050	0.0394	0.0233	-0.0352	0.0217	0.0058	0.0335	**-0.124**
Grain yield/ plant	**0.0362**	**0.0342**	**0.222***	**0.2034***	**0.095**	**0.7874****	**0.3844****	**0.0721**	**-0.160***	**-0.2109***	**0.1467**	**-0.1207**	**0.1062**	**-0.004**	**0.0222**	**-0.3239**
Partial r^2	-0.0014	0.0056	-0.0532	-0.4377	0.0122	0.8826	0.0191	0.0115	0.0478	0.0187	0.0141	0.0184	0.0161	0.0003	-0.0044	0.0402

R SQUARE = 0.5899 Residual Effect = 0.64404 Diagonal bold letters indicate direct effects

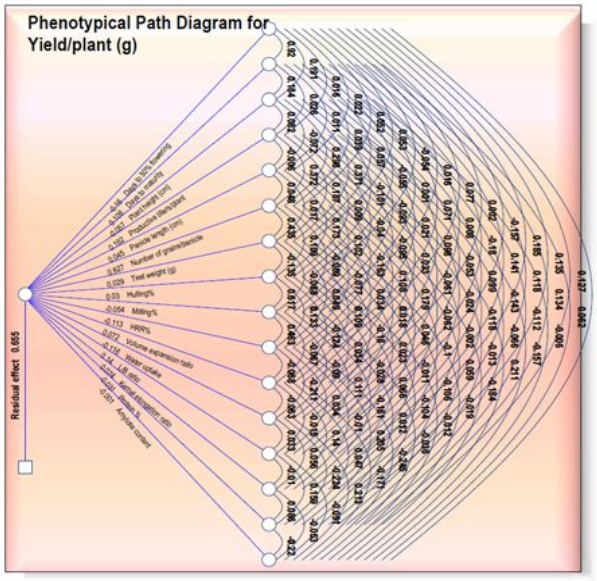

Figure 1: Phenotypic Path Diagram Showing Cause -Effect Relationship in Rice (*Oryza Sativa* L.)

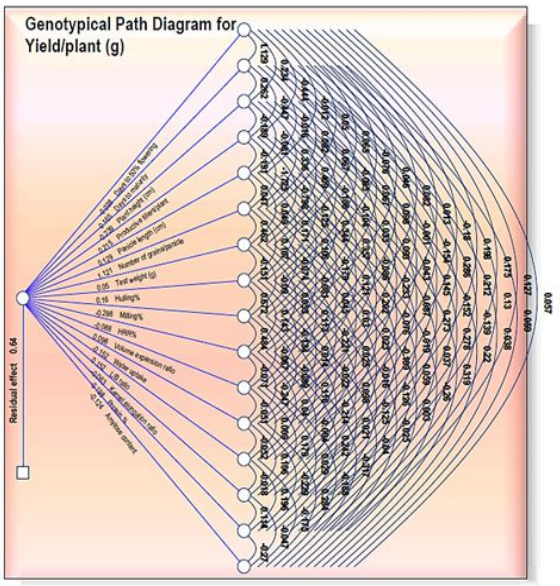

Figure 2: Genotypic Path Diagram Showing Cause-Effect Relationship in Rice (*Oryza Sativa* L.)